TRACE ELEMENTAL DISTRIBUTION AND SPECIATION IN TERRESTRIAL ENVIRONMENT AROUND KHETRI COPPER MINES, RAJASTHAN, INDIA

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Introduction

Pollutants present in the environment are degradable and non-degradable. Degradable pollutants can be easily decomposed in environment but the non degradable pollutants are responsible for major environmental problems. Degradable pollutants can be broken down into simpler, harmless, substances in nature in due course of time (by the action of micro-organisms like certain bacteria). Trace elements have average concentration of less than 100 parts per million (ppm) or less than 100 microgram per gram of an element (Shanker., 2008). Trace elements are ubiquitous in environment; Trace elements are also present in rocks, soil, air, water in and food. Some natural and anthropogenic activities are mainly responsible for increase in the concentration of trace elements. The main anthropogenic sources are mining activities, metal processing industries, fossil fuel combustion, incineration of wastes and sludge, leaching from garbage dumps etc. Metals (Cu, Zn, Mn, Fe, Ni, Mo, Co) and metalloids (B, Si, and Se) have an essential role as nutrients for plants and animals. While, heavy metals severely affect the growth (physiochemical and morphological) of plants species and also reduce the level of nutrients uptake. These pollutants are extremely harmful to both human health and environment.

Mining has been with us for thousands of years. Even the earliest mining operations during the copper, bronze and iron ages resulted in the production of gaseous, liquid and solid waste, In historic times, mine wastes were released into the environment with some of them causing contamination or even pollution on a local or regional scale. Environmental contamination is not new to the industrialized world. In the 20^{th} century some estimation suggest that approximately 20000-25000 million tones of solid mine wastes are produced annually around the world (Larsson et al., 2017). China at first position has caused a large generation of waste production, especially copper mining from sulphide ore leaves large amount of tailing .The annual discharge of mine tailing in

the world exceeds 10 billion tons (Adiansyah et al., 2015). China currently has more than 12,000 tailing ponds (Yin et al., 2011). India depends on over 3,100 mines out of which over 550 are fuel mines, over 560 are mines for metals and over 1970 are mines for extraction of non metals and 600 coal mines, 35 oil projects and 6,000 metalliferous mines. The country produces and works with roughly 100 minerals. There are about 17 working copper mines in India, The major copper mines are the Khetri copper belt in Rajasthan, Singhbhum copper belt in Jharkhand and Malanjkhand copper belt in Madhya Pradesh which are mined by HCL Mining production is just 0.2% of world's production, whereas refined copper production is about 4% of world's production. Rajasthan, Madhya Pradesh and Jharkhand are the only states involved in production of copper ore in the country. Global ranking is 4th in smelter production and 8th in refined copper consumption. Khetri copper complex having a milling capacity of 2,00,000 tones of copper ore per month. Approximately 25,000 tons / year (Mishra et al., 2008) of tailing are being generated and dumped in the open area tailing pond at Khetri without any treatment (Yadav and Rajamani, 2003). The composition of tailings is directly dependent on the composition of the ore and gangue as well as the process of mineral extraction used on the ore. The bulk quantity of tailings is very fine ground barren rock with significant quantities of metals found in the host ore and substantial amount of added compounds used in the extraction process (Lottermoser, 2007). Improperly disposed tailing are prone to wind and water erosion. The physical and chemical characteristics of tailings favour metal mobilisation to the environment. Principal ore minerals in Khetri copper mine are chalcopyrite ($CuFeS_2$), pyrite (FeS_2), pyrrhotite (Fe1-xS) , Silicate gangue and locally magnetite are source of contamination (Chen et al., 2015).

Mining activities generate four major categories of waste

- Mine waste (low grade ore, overburden, barren rocks)
- Tailing
- Dump heap leach
- Acid mine water

Mine water and tailing are generated from mining and mineral processing activities. They have detrimental impact on the local environment (Mishra et al., 2008). The tailing dominantly consist of ground –up gangue from which most of the valuable mineral has been removed. The solids are unwanted minerals also such as sulfide, hydroxide, carbonate etc. The grain size of tailing is relatively restricted and range from clay to sand. The grain size influences the resistance of the tailing solids to wind and water erosion and behavior and settling characteristics of particles in tailing dams (Yadav and Rajamani, 2003). The mineralogical and geochemical composition of tailings solids is site specific and such variations provide different challenges. (eg. sulfide rich tailing are potential source of Acid mine drainage (Downing., 2014).

Problems and its effects

The environment contamination with trace elements is considered a serious localized problem related to these activities. Mine tailing are products of mineral processing and generally deposited in open air tailing pond without any treatment (Babel et al., 2016). They are mixtures of sand, fine-grained soil material, water and significance quantities of heavy metals (Santibanez et al., 2011). Metal mining, smelting and processing throughout the world have contaminated soils with heavy metal in excess of natural soil background concentration. These processes introduce metal contamination in to the environment through gaseous and particulate emission and solid waste. Metal smelting and refining processes produces gaseous (CO_2, SO_2, NO_x) and particulate matter emission and solid waste as slag. The emissions of SO_2 from smelters contribute to soil acidity. Mine waste and smelting waste are the chemical contamination occurs as trace elements mobilization due to the weathering of solid inorganic material under exogenic conditions. These compounds and can be crystalline and or glassy. The weathering of slags appears to proceed by dissolution of unstable phases. The chemical and physical properties of waste and the prevailing environmental conditions affect the rate of weathering and therefore the rate of metal release. The incinerator slag and mine waste have indicated the metal leaching increase at higher redox potentials as the wastes are exposed to air in presence of water (Allard et al., 1980). These processes introduce metal contaminations in to the environment through gaseous and particulate emission, waste liquid and solid waste

(Dudka and Adriano, 1997). Sulfide rich tailings are potential source of Acid mine drainage. Acid mine drainage in which waste react with water and oxygen to produce an acidic environment that subsequently dissolves host rock mineral from the waste containing toxic metals and trace elements. Copper is one such metal of significance, as it is mined in a large volume in primarily sulphide containing copper ore (such as chalcopyrite) and other secondary ore are chalcopyrite, pyrite, pyrrhotite, silicate gangue and locally magnetite are main source of contamination. It has strong biocidal activities that greatly affect ecosystems. Mining cause great devastation of terrestrial and aquatic environment on local and regional scale, Tailings may have high sulfide content in the form of rejected pyrites and other sulfides. Sulfidic tailings are a potential source of AMD (Jambor 1994; Blower et al, 1998). If sulfidic tailing are exposed to atmospheric oxygen or to dissolved oxygen in the vadose zone tailing, the oxygen infiltating the waste may cause sulfide oxidation and trigger AMD and secondary mineral formation will occur and low pH and high concentrations of water dissolved constituents will be generated (Coggans et al, 1999; Johnson et al, 2000). Acidification is one of the major serious chemical threats in environment caused by sulfide ore mining. Soil acidification is caused by acid mine drainage from mines, tailings, subgrade ore piles and mining waste. Acid mine drainage decrease the pH of the mine water as well as adjacent soil. This usually results in increased mobility of metals. The effect of mining activities is one of the most dangerous depending on the metal being mined. Metals present in soil are easily accumulated by the crop and directly impact the human being (Chen et al.1999; Tripathi et al. 1997).

In the urban environment such pollutants are commonly found in street dust which are potentially harmful to roadside vegetation, wildlife and neighboring human settlements. Street dust is typically derived from anthropogenic sources via interaction of natural solid, liquid or gaseous materials with pollutant source such as water transports material from surrounding soil and slopes, dry and wet atmospheric deposition. Street dust has become the major source of pollution in the metropolis due to bad roads, industries and metal mining activity ingress the concentration of heavy metal. Children under the age of 5 are on most risk (Xintaras., 1992), Direct oral ingestion of contaminated soils and dust by children is the principle cause of trace element absorption. The presence of heavy

metals in the soil and dust in high concentration can affect the children health. Source of trace elements are mine waste, spreading of ash from incinerators, gas emission from cars, sewage sludge and chipping paint is significant source of contamination in soil near building (Xintaras., 1992) and is a problem in schools and residential area. Heavy metals can impair important biochemical processes posing a threat to human health, plant growth and animal life (Ward et al., 1977).

In monitoring urban pollution, chemical and biological indicators are of interest since it provides information on the concentration and accumulation of heavy metals in the ecosystem (Campbell., 1976, Ramlan and Badri., 1989). The most widely used test to evaluate polluted sites in the USA is the toxicity characteristic leaching procedure (USEPA., 1994). The TCLP is designed to determine the mobility of both organic and inorganic analysis, heavy metal present in liquid, solid and multiphase wastes. According to USEPA toxicity characteristic leaching procedure can be used for the soil characterization and determination of how much material may leach into the groundwater from the sites and therefore poses a risk to humans living off-site through groundwater contamination (Mica., 1999). GJST is good screening test to detect of soil and dust contaminated sites and to avoid pollution in young children. It should not, however, be used to run precise toxicity studies. A risk analysis demonstrating the safe use of soils exceeding these values may allow the residential use of more highly contaminated soils (MEFQ., 1998).

Acid-Base accounting is primary method to evaluate the acid or alkaline potential of geological material and to predict if weathering of these materials will have adverse effect on terrestrial and aquatic environment. The acid base accounting procedure has been used to evaluate mine soils at different stages of weathering. ABA is the fastest and easiest way to evaluate the acid forming characteristics of overburden material. Acid-Base accounting is prediction tool it has ability to predict whether earth- disturbing activity such as mining, construction of pipelines and highways or disposal of dredged material, may produce acidity through the exposure of sulfide containing minerals to the atmosphere (Fisher and Brown, 1994). The concept for Acid base Accounting (ABA) arises from ideas based on the composition of the earth's crust. ABA is based principally

on acidity or alkalinity and rock type, Acid forming materials were identify and handle in a manner to control the impact on surface and groundwater with minimum adverse effects on the plant growth. ABA was proposed in 1976 and the final field and laboratory procedures for the method were published in 1978 (Sobek, et al., 1978). The ABA consisted of five components: Acid potential, neutralization potential, pH, rock types and depth below the land surface (Sobek et al., 1987). This method balances maximum potential acidity against total neutralized. Neutralization potential (NP) is base the content of overburden material, including carbonates minerals, exchangeable bases and weatherable silicate minerals rocks (Sobek et al., 1978) other easily weatherable minerals and exchangeable cations on clays are included in the NP. The basic components in an unweathered overburden may be sufficient to equal or exceed the potential acidity of the material. Neutralization Potential and Potential Acidity are both measure of material's maximum potential to produce either alkalinity or acidic in nature.

Metal toxicity depends on chemical associations in soil. For this reason, determining the chemical form of a metal in soil is important to evaluate its mobility and bioavailability. It is increasingly being realized that the distribution, mobility and biological availability of chemical elements depend not simply on their concentration but critically on chemical and physical associations which they undergo in their natural systems. A widely used technique to understand element distribution in the solid phase is known as fractionation, following the international union of pure and applied chemistry (IUPAC) definition (Templeton et al., 1999) is based on the application of sequential selective chemical extraction also called as "speciation schemes" (Gleyzes et al., 2002). The IUPAC has defined speciation as "the analytical activity of identifying and measuring the quantity of one or more individual chemical species in a sample" and the speciation of an element as "the distribution of defined chemical species of an element in a system".

Sequential extraction is a useful technique for determining chemical forms of metal such as soil, sediments and different anthropogenic material. Different schemes of sequential extraction techniques have been widely applied to soil contamination by mining operations (Durn et al., 1999; Garcia et al., 2008) as well as to tailings. These techniques are mostly designed to differentiate between metals bound in exchangeable and adsorbed,

acid soluble reducible, oxidisable and residual fraction. Speciation is necessary tool to provide the information about bioavailability, mobility and distribution of potentially toxic elements. Single and sequential extraction schemes have been designed for the determination of binding form of trace metals in the solid matrices. The concept of the sequential extraction (SE) procedure is the partitioning of a solid material into a specific phase or fraction from which it can selectively be extracted; these methods are based on the rational use of a series of more or less selective reagents chosen to successively attack different mineralogical fractions thought to be responsible for retaining the larger part of the trace element (Gleyzes et al., 2002). Sequential extraction will provide a good insight into the sequence of metal leaching behavior through determination of metal fractionation or association with different mineral phase in the solid matrix of the mine waste. The sequential chemical extraction procedure reported by Terrier et al. (1979) and BRC procedure elaborated in 1993 by the standards, Measurements and Testing program are the most representative schemes. Single extraction test are commonly used to study the eco toxicity and mobility of the metal in a soil, eg. To assess bioavailable metal fraction and environmentaly accessible trace metals upon disposal of sediment or wastes on a soil (Anju and Banerjee, 2011). The effect of mining activities is one of the most dangerous depending on the metal being mined. Metals present in soil are easily accumulated by the crop and have a direct impact on the human beings (Chen et al., 1999; Tripathi et al., 1997). Metal such as Cu, Fe, Mn, Zn are essential for organism's growth, while Cd and Pb are not biologically essential. but cause adverse health impact like renal failure, liver damage etc (Sathawara et al., 2004). Most of the earliest studies on metals have been limited only to the determination of their total concentration. Street dust pollution in urban areas has an important impact on the environment. Human health and life quality of residential area, the health of children and adults was affected by inhaling or ingesting street dust with the high metal contamination. Urban pollution and road activity often caused air pollution and adverse human health effects such as lung cancer, hypertension and cardiovascular disease. Due to the accumulation of metals in street dust with atmospheric deposition by sedimentation interception, human health may be adversely affected by air pollution if metal concentrations reach a level of being considered as toxic pollutants.

Literature Review

Sequential extraction procedures are applied to wide variety of matrices such as soil (Anju and Banerjee, 2011) and tailing (Anju and Banerjee, 2010; Sidle et al.1991) and street dusts (Anju and Banerjee, 2003). In all of the sequential extraction procedures reported in literature, different chemical reagents are applied in order of increasing reactivity (Tessier et al., 1979; Mileusnic et al., 2014). These Techniques are usually based on the principal of successive extraction of conceptually distinct lithological or authigenic fractions representing a range of element forms, These techniques are mostly designed to differentiate between metal bonding (Mileusnic et al., 2014) and from the most mobile to those strongly bound to the support mineral (McGrath., 1996). The fraction or proportion of the individual element in each phase depends on the chemical reagent used as the extractants, the chemical and physical operating parameter involved, such as pH, reagent type, concentration time of contact, particle size, stirring system temperature etc (Smichowski et al., 2005). Many of the sequential extraction methods are, in fact, variants on the Tessier procedure (Tessier, et al., 1979), in which the exchangeable metals and those nominally associated with carbonate, Fe-Mn oxides, organic material, and silicate residues are extracted with different reagents (Quevauiller, 2002). Based on the Tessier procedure, the community Bureau of Reference of the commission of the European Union produced the definition of an extraction protocol (the BCR protocol) and a purely operational definition of sequential fractionation. This method partitions the heavy metals into fractions: exchangeable and adsorbed, acid soluble (carbonate bond), reducible (oxides, hydroxides and oxyhydroxides), iron and manganese oxides bound, organic matter bound and residual metal (Mileusnic et al, 2014). Heavy metal pollution from copper mine waste are hazardious to the environment, Trace elements were measured using X-ray diffraction (XRD). High contents of Zn, Cu, Ni, Cr, Cd,Co, were found in the tailing.

According to simple and fast screening test to detect soils pollution by using toxicity chacacteristic leaching procedure (TCLP) and Gastric juice simulation test (GJST). TCLP and the GJST were compared for various size fractions to determine chemical availability of the trace element in the soil, The GJST better simulated the chemistry of the trace

elements because TCLP used no chloride, a relatively high pH (~ 5) and low temperature (20^0C) (Mercier et al., 2002). TCLP fluid does not have enough free protons (acid) to leach more trace elements from small size fractions. TCLP did not show strong contamination in the less then 2mm size fraction in this soil. The TCLP is not able to efficiently solubilize trace element from soil as the gastric juice or the GJST can do The GJST is thus a better tool then the TCLP for detection of the soil and dust contamination. GJST is good screening test to detect trace element contaminated soils to avoid pollution in young children. The GJST screening test is simple and better test to detect of soil and dust contaminated sites and to avoid pollution in young children.). Another study of leaching of metals from soil contamination by mining activity by Yukselen and Alpaslan., (2001) it relates toxicity characteristic leaching procedure (TCLP) on the soil sampling treated with soil sample, lime soil and cement/ soil. The stabilization was evaluated by applying leaching test. TCLP test was on the soil sample treated with lime at additive / soil mixing ratios showed that Cu and Fe solubility was reduced. The result of cement treatment using toxicity characteristic leaching procedure (TCLP) and it was found that the degree of heavy metal leaching is highly dependent on pH. A study has been carried out by Zejun et al., (2018) on the heavy metal speciation and leaching behavior from a type spent selective catalyst reduction (SCR) catalyst containing high concentration of copper, zinc, nickel, lead. A three step sequential extraction method, toxicity characteristic leaching procedure (TCLP) and leaching characteristic test have been performed. It was found that leaching rate was positively correlated with available contents (sum of acid soluble, reducible and oxidizable fractions). Leaching characteristics test indicated that pH substantially affected the leaching of this heavy metal. The leaching of Cu, Zn, Cr, and Ni was positively influenced by strong acid and easily released in the presence of strong acid and strong alkali. The distribution of heavy metals is an important indicator to estimate the toxic response and ecological risk of heavy metal in waste (Ho and Evans, 2000; Nemati et al., 2011). An improved three step BCR (Li et al., 2016) is commonly used because of its wide range of applicable substances, including coal ash, fly ash and tailing waste. Toxicity characteristic leaching procedure (TCLP) is standard toxic leaching method. It is mainly used to detect the dissolution and migration of heavy metal in solid media or waste. Leaching test

investigate the behaviors of heavy metal and prediction of metal leaching behavior during utilization and harmful impact on the environment and human health. A study carried out by Ettler et al., (2019) the bio accessibility methods have been used at mining sites to assess the human exposure to contaminants from soils urban indoor and outdoor dust (Reis et al., 2014; Hervey et al., 2016) mine tailings and smelter derived materials such as slags and fly dust.

Another study on the Acid mine drainage generated by Malanjkhand copper mine was done by Pandey et al., 2007. Acid mine drainage occurs when sulphide bearing to air and water, changing the sulphide to sulphuric acid. This acid can dissolve heavy metal found in waste rock and tailings such as lead, zinc, copper, arsenic, selenium, mercury and cadinium in to the water and surface water. Certain bacteria increase the rate of this reaction AMD and heavy metal pollution can poision ground and drinking water. Another study on the assessment of heavy metal contamination by Punia and Siddaiah, (2017) on the khetri copper mine, calculate the contamination index of environment risk for the heavy metal of the groundwater sample. The mobility of toxic metal from mine tailing show a wide compositional range is examined by sequential extraction producer in order to assess their mobility when these waste are in tailing pond (Anju., 2018). Extraction Methods involve the complete or selective mobilization of toxic metals associated with the solid phase by extraction with mine waste water or tailing. A study has been carried out by (Mishra et al., 2007) on the mine tailing or Acid mine drainage contain toxic metals that can be release in to the environment through the metal smelting process and through the bioleaching during disposal /copper solubilizing/ recovery tailing waste. The evaluation of the optimum time for bioleaching of the toxic metals are present in the mine tailing was determined using adapted strain of *Acidithiobacillus ferrooxidans* (Thavamani, et al., 2017). A study has been carried out on the determination of heavy metal pollutants in the street dust and observed the concentration of the Zn, Pb, As, Cu, Ni, Cr and Cd in the dust samples (Shinggu et al., 2010). Chromium, cadmium and nickel are among the toxic listed element by the international agency for research on cancer calculate and provide the information on the concentration and accumulation of heavy metal threats on the human health, plants growth and animal life. A range of metals and chemical compounds found in the street dust environment are harmful. A study carried

out by Hossner and Brabdt (1997). Acid Base accounting method to evaluate the acid or alkaline potential of geological material and to predict if weathering of these materials will have adverse effect on terrestrial and aquatic environments. According to Perry, (2015) acid-base accounting is one mechanism for assessing post mining water quality. Its utility is amplified when used in conjunction with other pre mining information including water quality, examination of adjacent and previous mining and evaluation of geologic and hydrologic conditions.

Study area

In India, very scanty information is available on the soil pollution due to copper mining (Pandey et al., 2007). Khetri is famous for copper mining since historical time and it is located in the Jhunjhunu district of Rajasthan, India. It is about 180 km northeast of Jaipur, and 200 km southwest of New Delhi. The Khetri copper mines are located in north-western part of Aravalli mountain range of Rajasthan. India has been the centre of copper mining activity in the historic past, even long before the first geologist Hackett (1877), examined the region towards the end of nineteen century. Recent development of khatri copper complex was started by National Mineral Development Corporation (NMDC) and the project was handed over to Hindustan copper Ltd. (HCL) in 1967. The plant was designed by M/s Venot-Pic-Ense, France and commissioned in July 1973 to treat sulphide ore containing 1.00% copper (Kundu et al., 2014). Smelting and refining facilities were added. Khetri copper complex is about 8km away from the older khetri, connected by road and an aerial ropeway. The complex occupies a lower ground and is encircled by mineralized hills, the valley of which also serves as the dump or pond for the tailing generated. The side west of the pond overtaking the hills is uninhabited with undulated and hilly terrain, The area located at an altitude of 550 m above mean sea level with geographic location, latitude N $28^0$04.070' and longitude E $75^0$49.294'. The area falls in sub-tropical, semi- arid region with annual rainfall around 500mm. During summer, temperature varies from 12 to 45^0C while in winter it ranges 2 to 25^0 C. In the region, dust stroms blow from south- western direction during summer (May-June) and from north-western direction in winter. These mines are active for the several decades and generate large quantities of sulfide rich tailing of overburden materials. Khetri copper

complex having a milling capacity of 2,00,000 tones of copper ore per month. Approximately 25,000 tons / year of tailing are being generated and dumped in the open area at Khetri (Mistra et al. 2008), Mining activity along with agriculture activities lead to metal contamination of soil and cause adverse health impacts like liver damage, renal failure and chronic toxicity over humans and animals. The major concern of North-western and south- western areas is contamination, persistence and risks of metals in the environment (Chen et al.1999; Tripathi et al. 1997). Yadav and Rajamani (2003). observed that KCC mines as the source of higher cooper levels in the aerosols of Delhi.

Need for the Study

Copper is mined at large volume in sulphide containing ores. Copper mining are the point source of the trace elements in environment. Mining and mineral processing plant generated large volume of mine waste. Approximately 20000-250000 million tones of solid mine waste are annually produced around the world. It has been noticed that there is no systematic study of soil, tailing (fresh and aged), street and household dust and waste regarding mobility and speciation of trace elements for Khetri copper mine. The outflow of acidic water from some mine waters, known as acid mine drainage (AMD). It is one of the unwanted consequences of metal mining activity and created environment and water quality problems.(Taylor et al., 2005). Acid mine drainage is naturally in mine waste. Which residued sulphide minerals such as pyrite are oxidized in the presence of oxygen (air) and water. The resulting oxidative weathering of sulfide can generate H^+ and release sulfate and metals in tailing pore waters (Blowes et al, 2013, Lindsay et al, 2015). Sulfides bearing mine tailings are a serious environmental problem and increase the pollution risk to groundwater, agriculture field and human habitats from the sulfide tailing. The soil pollution and ground water will increase the hardness, conductivity, chloride, sulfate and bicarbonate in the groundwater caused by the copper smelter at Khetri. The khetri copper mine generate large number of soil, air and ground water pollution may cause damages to the environment and ecosystem. It is recognized that the health hazards and impact from copper mining plant result from the mobilization of toxic element from copper mining and smelting. They cause respiratory problems (such as asthma, coughing, chest pain and choking), skin irritation, eye problems, headaches and

cancer. The copper mine release harmful waste product that has high levels of sulfur. Lack of information on various aspects of copper mines limits the effectiveness of waste management. As per the available literature, It has been noticed that there is no systematic study of soil, tailing (fresh and aged), street and household dust and waste regarding mobility and speciation of trace elements for Khetri copper mine. This makes it more important to investigate document and report the various aspect of KCC mines. So, the main objective of the proposed study is to investigate the distribution and speciation of trace elements in the terrestrial environment around Khetri copper mine.

Objectives

In the light of forgoing discussion the objectives of the proposed research work are:

- To sample the soil profile (along two transects from the tailing dam), tailing profile (fresh & aged) and house / street dust from the Khetri copper mining area.
- To investigate the trace elemental (Cu, Zn, Co, Ni etc.) distribution in soil profiles, mine tailing profiles and dusts.
- To determine the trace elemental speciation in soils and tailings by using single and sequential extraction procedures.
- To compare the efficiency and selectivity of two sequential extraction procedures (SEPs) applied to tailings and dust.
- To assess the bioavailability of metals in dust and tailings by various leaching procedures.
- To predict the acid mine drainage formation in mine tailings by using acid base accounting method.

Methodology

Soil

- Sampling of soil profile along two transects from the tailing pond of Khetri copper mine to assess whether the levels of trace elements in soil are related to the dispersion of tailings by wind or other modes.
- Sampling of soil profile around derelict smelting sites.

- Physico-chemical characterization (pH, EC, TOC, PSA and some heavy metals Cu, Zn, Co, Ni etc.) of soil sample would be taken
- Single and Sequential extraction would be used to assess the trace elemental speciation.

Tailings

- Sampling of tailing (fresh and aged) profiles
- Physico-chemical characterization (pH, EC and some heavy metals Cu, Zn, Co, Ni etc.) of tailing sample would be taken
- Single and Sequential extraction would be used to assess the trace elemental speciation in tailing.
- To compare the efficiency and selectivity two SEP would be applied to the tailing samples.
- To predict the acid mine drainage formation in mine tailings by using acid base accounting method.
- To assess the bioavailability of metals in tailings various leaching test would be applied to the tailing sample.

Household / street dust

- Dust sampling from the residential area.
- Sequential extraction would be used to assess the chemical partitioning of trace elements.

Instrument required:

pH meter, EC meter, Double beam spectrophotometer, Atomic Absorption spectrometer, Shaker, Oven, and Centrifuge etc.

Significance of proposed study:

This research work will provide the information about level of heavy metal and their potential mobility in the area around Khetri copper mine. Several chemical methods will be used for analyzing the heavy metals distribution and speciation in soils, tailings and house/ street dust. The outcomes of the study will allow a detailed assessment of present and future environmental risks arising from tailing weathering. This will also provide solutions to assess the remediation possibilities of the contaminated sites, so that the adverse environmental and ecological impacts of Khetri copper mine can be mitigated.

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